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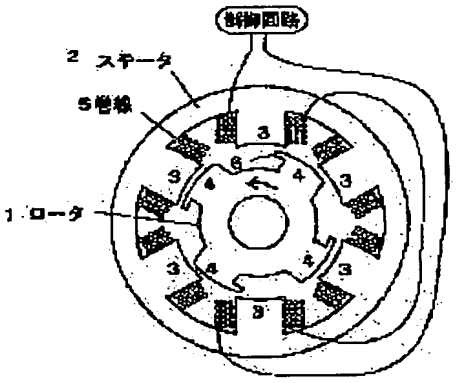
(54) SWITCHED RELUCTANCE MOTOR AND ITS CONTROL METHOD

(57)Abstract:
PROBLEM TO BE SOLVED: To concentrate magnetic flux flowing into a rotor-side wall surface on the side surfaces of a protrusion when a salient rotor pole begins to face a salient stator pole, to increase magnetic flux flowing-in in the peripheral direction, and to increase the torque and efficiency, by forming a protrusion stretching in a rotating side peripheral direction and having a plane at its rotating side end, at the tip of each salient rotor pole.
SOLUTION: A reluctance motor rotates by switching-controlling current flow into exciting windings 5 wound on salient stator poles 3 according to the positional relation between the rotor 1 and the stator 2. Here, a protrusion 6 extending in a rotating peripheral direction is provided at the tip of each salient rotor pole 4, and its tip is formed into a plane. And magnetic flux, which is generated by current flow into the exciting windings 5 when a salient rotor pole 4 begins to face a salient stator pole by the rotation of the rotor 1, and flows into the wall surface of each salient rotor pole 4 from a salient stator pole 3 through an air gap, is concentrated on the protrusion 6. Consequently, it becomes possible to increase the peripheral-direction component of a magnetic flux density in the vicinity of the peripheral surface of the rotor 1, and to increase its torque.



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CLAIMS

[Claim(s)]
[Claim 1] It is the switched reluctance motor characterized by the tip of owner Perilla frutescens (L.) Britton var. crispa (Thunb.) Decne. being a flat surface about the projected part extended to a rotation side circumferencial direction at the tip of the Rota salient pole in the switched reluctance motor made to rotate this Rota by attracting the Rota salient pole which carried out sequential energization of the excitation winding coiled around two or more stator salient poles established in the stator, and was established in Rota.

[Claim 2] The ratio of the height of a projected part and the height of the Rota salient pole is a switched reluctance motor according to claim 1 characterized by being 0.05-0.3.
[Claim 3] The switched reluctance motor according to claim 1 characterized by making the ratio of height [in / at least / a point] into 1+60% and -80% of range with the wire extension of a projected part.
[Claim 4] The switched reluctance motor according to claim 1, 2, or 3 characterized by changing the wire extension of a projected part in the direction of a revolving shaft.
[Claim 5] Claims 1-3 characterized by a tip having a plane projected part at the tip of the opposite side of the hand of cut of the stator salient pole which counters a motor, or a switched reluctance motor given in four.
[Claim 6] Claims 1-4 characterized by having Rota which covered with non-magnetic material at least the Rota front face except the side-attachment-wall side front face which has an opposite side front face and a projected part with a stator, or a switched reluctance motor given in five.
[Claim 7] Claims 1-5 characterized by having Rota which formed the configuration of the connection part by the side of the shaft of a projected part and the Rota side attachment wall gently-sloping, or a switched reluctance motor given in six.
[Claim 8] It is the control approach of the switched reluctance motor characterized by detecting the location of Rota by making the tip of owner Perilla frutescens (L.) Britton var. crispa (Thunb.) Decne. into the flat surface in the projected part which extends a switched reluctance motor to a rotation side circumferencial direction at the tip of the Rota salient pole, and detecting the energization current wave form of the coil wound around the stator salient pole in the location where the stator salient pole and the Rota salient pole started opposite.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the control approach of not using especially the efficient drive and sensor, about amelioration of a switched reluctance motor (henceforth SR motor).
[0002]
[Description of the Prior Art] The conventional SR motor consists of Rota 1 and the stators 2 which carried out the laminating of the magnetic-substance sheet metal, such as a silicon steel plate, as shown in drawing 16 . Rota salient pole 4 -- and stator salient pole 3-- are formed in Rota 1 and a stator 2, respectively, and each stator salient pole 3 by the side of a stator 2 is looped around the coil 5.
[0003] And a control circuit 13 detects the location of the Rota salient pole 4 in Rota 1 by a sensor etc., supplies an electrical-potential-difference pulse to a coil 5 according to the location of Rota 1, and carries out sequential excitation of the stator salient pole 3. By the magnetism by this excitation, each Rota salient pole 4 in Rota 1 is attracted, and Rota 1 rotates.
[0004] As a Prior art about this SR motor, Rota of a configuration which is indicated by above-mentioned drawing 16 is common. As a special configuration, SR motor (conventional example 1) indicated by JP,8-126273,A has prepared the projected part which becomes narrow in both sides, by reducing the amount of saturation magnetic flux of the Rota salient pole, can avoid the appearance of a torque peak and can control torque fluctuation as are shown in the drawing 1 and it goes at each tip of a salient pole of Rota along with a rotation circumferencial direction at a projection and tip side.
[0005] Moreover, in case this SR motor is driven, in order to switch the timing energized to each coil, the Rota location needed to be detected correctly and the axial location sensor which detects the rotation location of Rota is used. The sensor loess control technique which does not need an axial location sensor is also proposed and examined from before. For example, after the time amount set to the coil by the sampling-time circuit after electrical-potential-difference impression, SR motor control equipment (conventional example 2) indicated by JP,63-202294,A carries out the sample of the current, asks for the gap with the desired Rota location by the comparison with a reference sign, answers this error signal, controls a power circuit, and is controlling the exciting current. Therefore, the complicated circuit as shown in the drawing 1 A is used. In addition, the configuration of Rota of the conventional example 2 is shown in the drawing 1 . This is the normal mode as shown in drawing 16 , the side face of the salient pole in Rota is perpendicular, and the projected part of the taper of the both sides at the tip of the Rota salient pole like the conventional example 1 is not prepared.
[0006]
[Problem(s) to be Solved by the Invention] Drawing 16 is the sectional side elevation of SR motor of the conventional normal mode. According to Rota 1 of such a configuration, it thinks from the inflow condition of the line of magnetic flux from the stator salient pole 3 to the Rota salient pole 4, and the running torque produced in the opposite process of the Rota salient pole 4 and the stator salient pole 3 has become the configuration which is not acquired enough. Hereafter, drawing 17 which is an important section enlarged drawing explains the cause of the torque loss.
[0007] In order for a reluctance motor to obtain the running torque of an arrow head counterclockwise, the circumferencial direction component of flux density needs to act on the front face of the Rota salient pole 4. The momentary reluctance torque in the include angle alpha of a certain Rota 1 and stator 2 is expressed by the following formula (1) by the stress equation of a maxwell.
[0008]
[Equation 1]

$$T\alpha = \int r \cdot f_\theta ds \qquad (1)$$

$$f_\theta = (H_r B_\theta)_r + (H_\theta B_\theta - HB/2)_\theta$$

ここで、

S:ロータ表面積

r:軸中心からの距離

f_θ:θ方向の応力

H_θ:θ方向の磁界

H_r:r方向の磁界

B_θ:θ方向の磁束密度

H:磁界ベクトル

B:磁束密度ベクトル

$(\ )_r$:r面に作用する応力

$(\ )_\theta$:θ面に作用する応力

[0009] In order to make running torque increase from a formula (1), the one where the vertical component of the field in which a field needs to carry out incidence aslant on a front face to the Rota peripheral face 7 (r-th page), and which carries out incidence to a front face to the Rota side-attachment-wall side 8 (theta side) is larger is good. Moreover, the direction where a field acts near the Rota periphery can aim at increase of running torque. However, as the Rota configuration used conventionally is shown in drawing 16 and drawing 17 , the Rota side-attachment-wall side 8 serves as a straight-line configuration. The example of a line-of-magnetic-flux Fig. in the field analysis in this configuration is shown in drawing 18 .

[0010] Drawing 18 is the case where the Rota salient pole 4 and the stator salient pole 3 have not countered. If the Rota salient pole 4 and the stator salient pole 3 have countered, the radial component of Rota will occupy most and the magnetic flux which flows into the Rota peripheral face 7 will not have contributed to running torque. Moreover, although incidence is carried out from the slanting upper part to a field and running torque is generated, with rotation of Rota, to the Rota salient pole peripheral face 7 which has not countered, an opposed face product increases, the field component which contributes to running torque decreases, and, finally it becomes zero to it. On the other hand, the inflow of the magnetic flux by the side of the Rota side-attachment-wall side 8 is inclining and flowing into the side-attachment-wall side 8, and both hoop direction and radial component are contained. Among these, the running torque in which a hoop direction (theta) component can be found by (1) formula is determined. Like drawing 18 , when the Rota salient pole 4 and the stator salient pole 3 have not countered, many hoop direction components are contained, but if both begin to counter with rotation of Rota 1, whenever [fluid inlet angle] will move to radial gradually, and reduction in running torque will arise. As mentioned above, running torque fell sharply with rotation of Rota 1, and there was a problem that fluctuation of torque became large.

[0011] Moreover, it sets on SR motor indicated by the conventional example 1. Since the projected part which becomes narrow is prepared as it goes to a projection and tip side along with the rotation circumferencial direction at the tip of Rota In case the Rota salient pole and a stator salient pole start opposite gradually from the time of un-countering, inflow magnetic flux comes to increase gradually with rotation of Rota, magnetic flux increases suddenly in the Rota salient pole like before, and they can control changing torque sharply. However, since it is limited to the Rota salient pole side which counters and whenever [fluid inlet angle / of a great portion of magnetic flux] has turned to radial, in running torque generating of Rota, the inflow location of the magnetic flux from a stator salient pole is an opposite effect, and produces the fault of falling in respect of a motor efficiency.

[0012] Moreover, in SR motor operation control indicated by the conventional example 2, although the coil current is sampled, since the variation of the coil energization current changed with rotation of Rota is small, many ripples are overlapped on a current and have the problem of reducing location distinction precision sharply, by SR motor with the conventional Rota structure.

[0013] This invention is made in order to cope with such a technical problem, it makes running torque increase on the whole, aims at improvement in effectiveness, and aims at offering SR motor which enables high precision sensor loess control by easy circuitry while it makes whenever [magnetic-flux fluid inlet angle] change into a hoop direction side and controls fluctuation of the Rota running torque by modification

of the tip configuration of the Rota salient pole 4.
[0014]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, the following means are provided in SR motor of this invention.
[0015] The field of the hand of cut extended to a rotation side hoop direction forms a plane projected part at each tip of the Rota salient pole, even when opposite with the Rota salient pole and a stator salient pole starts, the magnetic-flux inflow to the Rota side-attachment-wall side concentrates invention according to claim 1 on a projected part side face, and it is changed in the direction of the Rota periphery, the inflow magnetic flux of a hoop direction increases, and torque reduction is controlled.
[0016] Invention according to claim 2 gives a ratio with suitable height of a projected part and height of the Rota salient pole, and claim 3 gives a value with the suitable aspect ratio of a projected part. Since extreme concentration of the flux density at the time of this passing reduction and the projected part of the amount of magnetic flux which flow from a stator salient pole is avoidable, the saturation of the magnetic flux at the time of high-speed rotation and high torque rotation is eased, and the fall of running torque can be avoided.
[0017] Invention according to claim 4 changes the die length of the projected part extended to the Rota salient pole tip hoop direction in the direction of a revolving shaft. It can become possible to shift the maximum running torque generating stage in the direction of a revolving shaft by this, the exciting force to the stator produced at the time of the maximum running torque generating can be reduced, and vibration by torque fluctuation and the noise can be controlled.
[0018] Invention according to claim 5 makes a projected part extend also at the tip of a stator salient pole to an anti-rotation hoop direction while preparing a projected part in the Rota salient pole tip hoop direction. Thereby, a change is made more to a hoop direction and the inflow magnetic flux on a stator and the front face of Rota of the side which counters can also attain the increment in running torque.
[0019] Invention according to claim 6 covers with non-magnetic material the Rota front face except the side-attachment-wall side front face which has the projected part extended to the Rota salient pole tip hoop direction, and has an opposite side front face and a projected part with a stator salient pole. Since the inflow location of the great portion of magnetic flux on the front face of Rota is limited to an opposite side front face with a stator, and a projected part side side face and can inhibit the leakage of the magnetic flux to other fields by this, in order to rotate Rota, the effective force can be increased, and it becomes possible to contribute to improvement in torque.
[0020] Invention according to claim 7 made gently-sloping the include angle of the connection part by the side of the shaft of the Rota side attachment wall of the root in the projected part extended to the Rota salient pole tip hoop direction. Since the direction can be made to be able to change greatly, and can control the inclination for magnetic flux to concentrate by the corner and the magnetic saturation at the time of magnetic flux passing through the inside of Rota can be controlled in case the magnetic flux which passes a projected part flows into the Rota body by this, more magnetic flux can be slushed now and improvement in torque is attained.
[0021] Invention according to claim 8 relates to the control approach of the above switched reluctance motors. Since it has the projected part extended to the Rota salient pole tip hoop direction and the magnetic flux from a stator and the stator in the opposite early stages of Rota flows intensively from the projected part side at the tip of Rota, Since a coil energization current can change sharply, can detect this and can ask for the Rota location, even if it does not use a complicated circuit like before, the detection precision of the control system which does not use a sensor can improve sharply, and can contribute to improvement in a motor efficiency greatly.
[0022]
[Embodiment of the Invention] Drawing 1 is the sectional view in the gestalt of operation of the 1st of this invention showing a stator 2 and the relation of Rota 1. The reluctance motor is constituted by the stator 2 which was constituted by the laminating of magnetic materials, such as a silicon steel plate, and was fixed to casing, and Rota 1 which has been arranged pivotable in this stator 2 interior, and was similarly constituted by the laminating of magnetic materials, such as a silicon steel plate, as shown in drawing 1 .
[0023] Stator salient pole 3 -- of a large number arranged at equal intervals is formed in the inner circumference side of a stator 2. Moreover, Rota salient pole 4 -- of a large number arranged at equal intervals is formed also in the Rota 1 periphery side. Moreover, the coil 5 for excitation is wound around the stator salient pole 3 established in the stator 2.
[0024] By the magnetism generated by carrying out sequential energization to excitation winding 5, the Rota salient pole 4 can draw SR motor near in the stator salient pole 3 and the direction where it counters, and

Rota 1 rotates it. Therefore, a rotary encoder etc. detects the rotation of Rota 1, according to the physical relationship between the stator 2 and Rota 1, by switching the timing energized to excitation winding 5 by the control circuit 13, it rotates continuously and the function as a motor is achieved.

[0025] Here, it has the projected part 6 extended to a rotation hoop direction at Rota salient pole 4 tip, and, in the tip, the structure of Rota 1 by the gestalt of the 1st operation has become a flat surface, as is shown in drawing 1 . Although drawing 2 is the important section enlarged drawing, when the stator salient pole 3 and the Rota salient pole 4 have not countered, after magnetism occurs by energization to excitation winding 5 and magnetic flux passes through space from stator salient pole 3 tip, it flows into the Rota 1 interior from the Rota salient pole 4 again. Under the present circumstances, magnetic flux flows from the near Rota peripheral face 7 and the near side-attachment-wall side 8 which counter the stator salient pole 3. In order to concentrate at projected part 6 tip, the hoop direction component of the flux density in near Rota 1 peripheral face increases the magnetic flux which flows from the Rota side-attachment-wall side 8. Here, the torque which moves this Rota 1 to a hand of cut is expressed by (1) type, and when the increment in the hoop direction component of magnetic flux arises near the periphery of Rota 1, the increment in torque is acquired.

[0026] Drawing 3 shows the magnetic-flux vector distribution searched for in field analysis about the structure of above-mentioned Rota 1. From the projected part 6 at the tip of the Rota salient pole 4, magnetic flux concentrates, it flows and drawing 3 shows signs that the magnetic flux of a hoop direction component increases. The direction made into the flat surface which intersects a hand of cut contributes the tip of a projected part 6 to the increment in torque.

[0027] It is [at the time of a stator 2 and Rota 1 beginning opposite] the same, and drawing 4 shows magnetic-flux vector distribution. Since the magnetic flux which flows from the projected part 6 by the structure of this Rota 1 also [in the middle of opposite] has a large hoop direction component and is larger than drawing 4 , improvement in torque is accepted. [of the radial distance which acts]

[0028] In the gestalt of the above-mentioned operation, although it has said that a projected part 6 is only formed in the rotation hoop direction at the tip of the Rota salient pole, the configuration of this projected part is considered.

[0029] Drawing 5 is the sectional side elevation of the gestalt of operation of the 2nd of this invention, and makes the wire extension of a projected part 6 equivalent to the height in a point at least. The aspect ratio of a projected part is 1. The Rota salient pole 4 equipped with the projected part which has such an aspect ratio can control that local concentration of the magnetic flux which passes through the inside of a projected part by concentration of the magnetic pole to the projected part 6 shown with the gestalt of the 1st operation of the above-mentioned arises.

[0030] Drawing 6 shows the result of having examined the line of magnetic flux at the time of setting the aspect ratio of a projected part 6 as 1 in field analysis. Drawing 6 shows that concentration of the magnetic flux in the projected part 6 interior is eased. If a wire extension and height are not much small, there is little effectiveness, and since they will approach the condition that the projected part was lost if it becomes large, they need to select a dimension appropriately. First, the projected part for which it asked by numerical calculation is a rectangle, and the related Fig. of a Rota generating torque ratio (torque in case there are not torque/projected part when there is a projected part) is indicated to be the wire extension w and ratio (w/h) of height h to drawing 7 . It becomes max when w/h is 1. The location of a torque ratio 1 is the case where there is no projected part, in an abscissa 0. When w/h exceeds 1.7 and becomes long and slender, it turns out that effectiveness falls. In addition, drawing 7 is a value in case the ratio of projected part height h and height H of the Rota salient pole is about 0.13. When this ratio h/H becomes still smaller, that effectiveness falls gradually. Even if ratio h/H becomes not much large too much, the torque component which pulls Rota to a rotation hoop direction decreases, effectiveness falls, and there is the optimal range in the ratio. The range of this range is drawing 8 to 0.05-0.3.

[0031] Drawing 9 is the sectional side elevation showing the gestalt of operation of the 3rd of this invention. Forming a projected part 6 in salient pole 4 point is changing the width of face 9 of this projected part 6 in the direction of the Rota revolving shaft with the gestalt of this operation, although it is the same as that of the gestalt of operation of until said. That is, it has the structure where the width of face of a projected part 6 was nonsequetially changed to shaft orientations continuously like drawing 9 (a) as shown in this drawing (b). According to Rota which has such a projected part, the amount into which magnetic flux flows from the projected part 6 of the Rota salient pole 4 in the same Rota angle of rotation will change with shaft-orientations locations. Therefore, since vibration which it is at the magnetic-flux inflow time, and is generated in Rota 1 and a stator 2 shifts in time and it generates, it becomes possible to reduce sharply the

noise resulting from vibration of the whole motor and it.
[0032] Drawing 10 is the important section sectional side elevation of the gestalt of operation of the 4th of this invention. In the gestalt of this operation, forming a projected part 6 at the tip of the Rota salient pole 4 has structure which formed the projected part 10 also at the tip of the stator salient pole 3 to the opposite side of a hand of cut with the gestalt of this operation, although it is the same as that of the gestalt of the aforementioned operation. According to this structure, the magnetic flux which flowed into space contains many hoop direction components from the projected part 10 at stator salient pole 3 tip, and also in case this flows into the stator salient pole 3 and the Rota peripheral face 7 of the side to counter, since it is continuing, an inclination is changed into the inflow magnetic-flux flow containing many hoop direction components whenever [this efflux angle]. Therefore, the increment in running torque expressed with (1) type is acquired, and improvement in effectiveness can be attained. Drawing 11 shows the line-of-magnetic-flux Fig. in field analysis. While the magnetic flux which flows out from the projected part 10 prepared at stator pole 3 tip from drawing 11 contains many hoop direction components, it turns out that it flows into the front face 7 of the Rota salient pole 4.
[0033] Drawing 12 is the important section sectional side elevation of the gestalt of operation of the 5th of this invention. With the gestalt of this operation, it adds to the above-mentioned Rota configuration of forming a projected part 6 in Rota salient pole 4 point. Since the Rota front face except the side-attachment-wall side 8 which has a stator 2, the Rota peripheral face 7 which counters, and a projected part 6 at least is covered with non-magnetic material 11, Since the inflow location of the magnetic flux in most Rota salient pole 4 front faces is limited to a stator, the Rota peripheral face 7 which counters, and the projection side Rota side-attachment-wall side 8 and can inhibit the leakage of the magnetic flux to other fields, In order to rotate Rota 1, the effective force can be increased, and it becomes possible to contribute to improvement in torque.
[0034] Drawing 13 is the important section sectional side elevation of the gestalt of operation of the 6th of this invention. Although it is the same as that of the gestalt of operation of until said to form a projected part 6 in the point of the Rota salient pole 4, the corner 12 is thickly formed so that the include angle of the connection part by the side of the shaft of this projected part 6 and the Rota salient pole 4 may be made gently-sloping. From the projected part 6 prepared at Rota salient pole 4 tip, the magnetic flux which flowed out from the stator salient pole 3 flows into the interior of Rota 1, and passes the one Rota inside-of-the-body section. Under the present circumstances, in a corner 12, magnetic flux is bent rapidly and the flux density in this point rises locally. Therefore, when the saturation of magnetic flux makes the energization current to a coil 5 increase at the time of a high speed and high torque rotation, it arises, and torque decreases. Then, if a corner 12 is made into the configuration made thick like drawing 13 , concentration of the magnetic flux which passes this part will be improved sharply, and reduction in torque will be eased. Drawing 14 shows the line-of-magnetic-flux Fig. in field analysis. Since the root by the side of the shaft of the projected part 6 prepared at Rota salient pole 4 tip was made thick, drawing 14 shows that concentration of the magnetic flux in a corner 12 is eased.
[0035] As a result of preparing the projected part extended to a hand of cut in the tip periphery of the above Rota salient poles, detection of the Rota location becomes easy. Drawing 15 is drawing showing the property of the relation between the coil current in this case, and Rota angle of rotation. It is in a condition when the constant-voltage pulse is impressed, a continuous line is a property at the time of using Rota by this invention, and a dotted line is a property at the time of using Rota of a conventional type like drawing 16 . As shown in drawing 15 , current change produced in the coil of the stator in the opposite initiation early stages of the Rota salient pole and a stator salient pole changes more rapidly than before. When detecting this current change and detecting Rota 1 conventionally, there was little current change and it was not appropriate for control of SR motor, but according to this invention, since detection precision can improve sharply, it becomes usable and can contribute to improvement in a motor efficiency greatly at a sensor loess control system.
[0036] It should be thought that the gestalt of the operation indicated this time is [no] instantiation at points, and restrictive. The range of this invention is shown by the above-mentioned not explanation but claim, and it is meant that all modification in a claim, equal semantics, and within the limits is included.
[0037]
[Effect of the Invention] As mentioned above, according to this invention, magnetic flux flows intensively from the projected part side established in the Rota salient pole point rotation hoop direction, and since the hoop direction component of the magnetic flux which contributes to torque generating increases, running torque improves.

[0038] Increase of an output torque can be aimed at without [therefore] saturating magnetic flux, even when the amount of magnetic flux increases by selecting appropriately the wire extension and height of a projected part which are prepared in the Rota salient pole point. It is effective in the amount of magnetic flux which flows the inside of a projected part easing concentration of magnetic flux, and the generating torque at the time of making an energization current high can be improved.
[0039] If the die length of the projected part extended to the Rota salient pole tip hoop direction is made into the configuration changed in the direction of a revolving shaft, a torque fluctuation component can be controlled.
[0040] While preparing a projected part in the Rota salient pole tip hoop direction, running torque is made to increase by preparing a projected part also at the tip of a stator salient pole to an anti-rotation hoop direction, and deflecting the magnetic-flux include angle which flows into a stator and the Rota front face of the side which counters to a hoop direction.
[0041] Since the Rota front face except the side-attachment-wall side front face which has an opposite side peripheral face and a projected part with a stator was covered with non-magnetic material, the magnetic flux generated from the stator can attain improvement in running torque by the increment in the magnetic-flux component which come to flow from the front face which does not cover non-magnetic material, and flows from the Rota tip hoop direction projected part especially. [many]
[0042] In the projected part extended to the Rota salient pole tip hoop direction, even when the root Motobe's height is made high, inflow magnetic flux enables it to deflect the flow direction to the Rota salient pole without resistance, and the magnetic-flux flow inside a rotor becomes smooth and enlarges an energization current, the magnetic saturation inside a rotor is eased, and since the flux density which flows into Rota in the same energization current increases, running torque can be increased.
[0043] Since current change produced in the coil of the stator in the opposite initiation early stages of the Rota salient pole and a stator salient pole by preparing a projected part in the tip hoop direction of the Rota salient pole changes more rapidly than before, this current change can be detected directly and the Rota location can be detected. It compares with the sensor loess control system to the former, and detection precision can improve sharply, it becomes more unnecessary [the circuit which cuts these noises] than few things, and the effect of the ripple superimposed on a current can also realize highly precise sensor loess control by easy circuitry.

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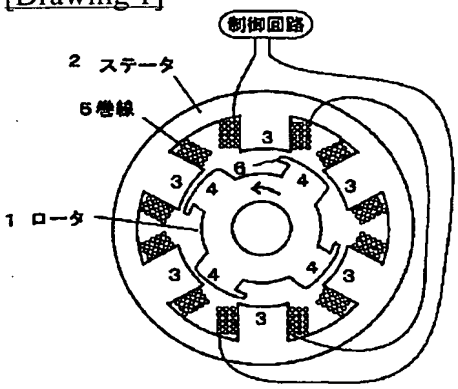
DRAWINGS

[Drawing 1]



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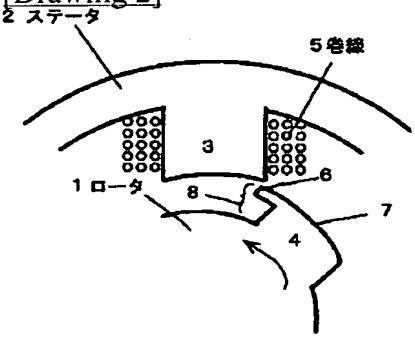

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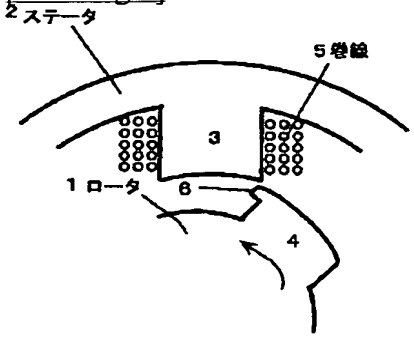

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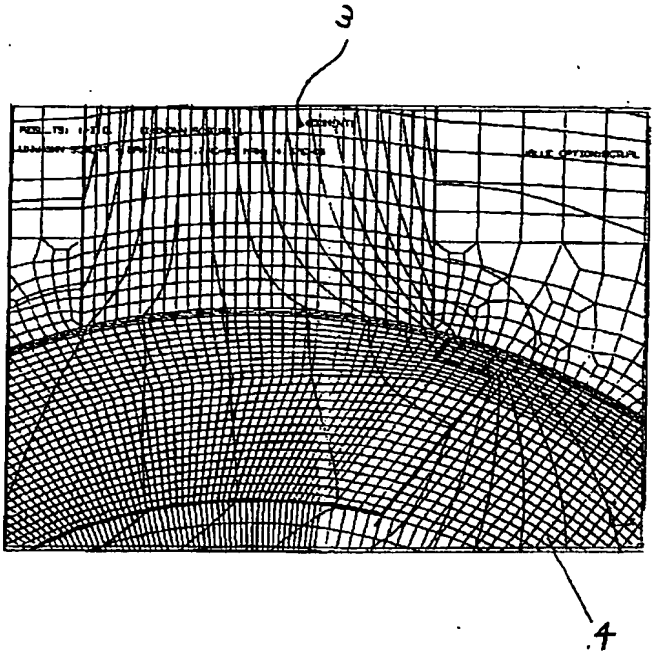

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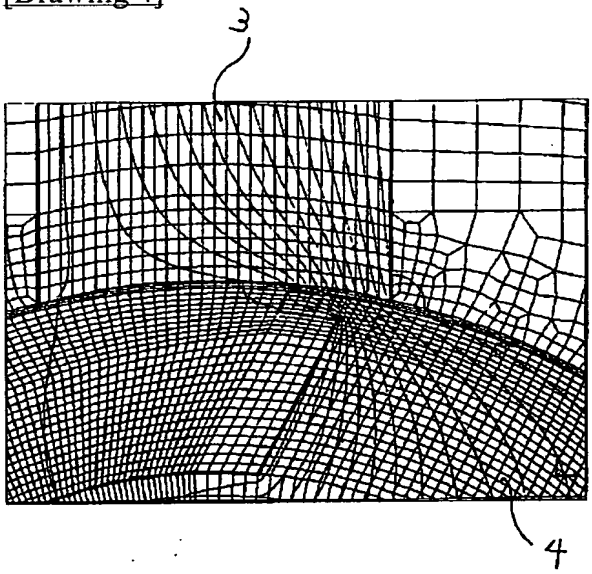
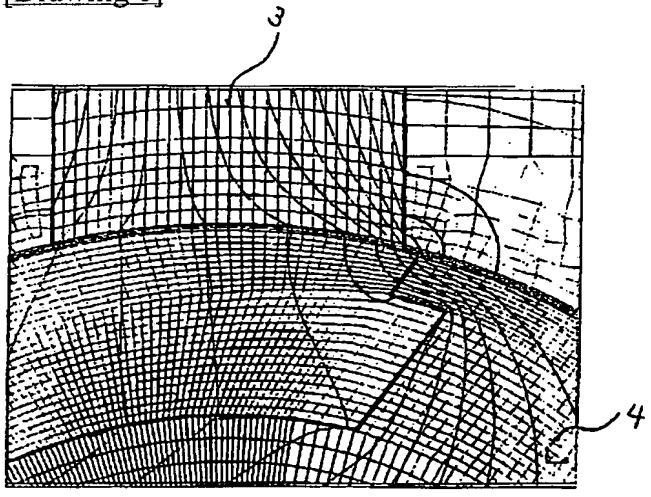
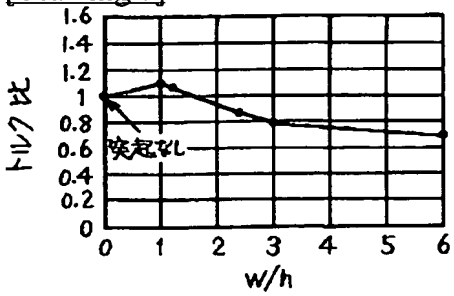


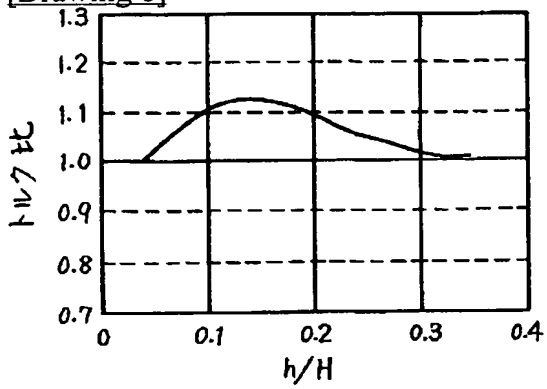
[Drawing 6]



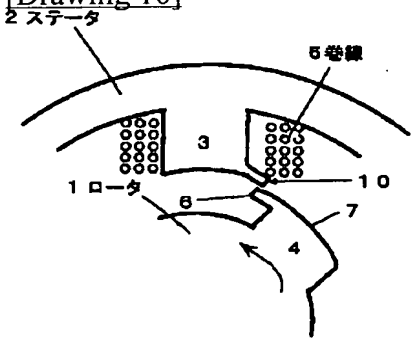
[Drawing 7]



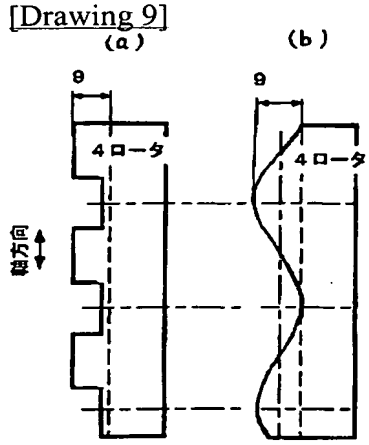
[Drawing 8]



[Drawing 10]



[Drawing 9]



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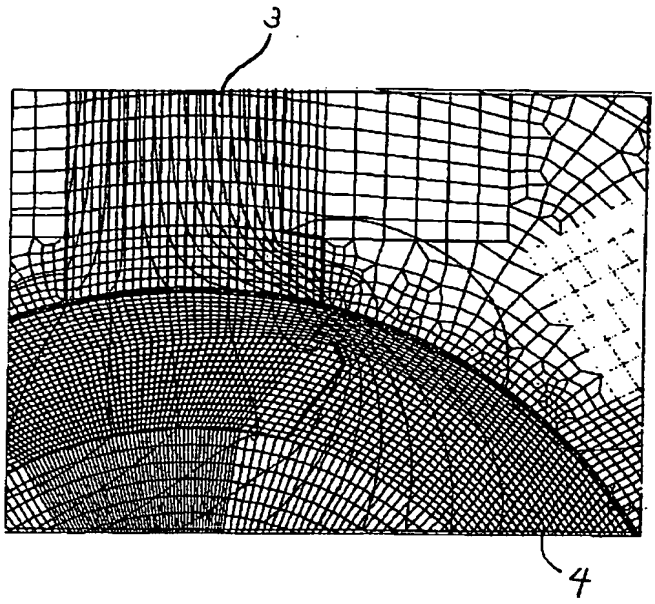
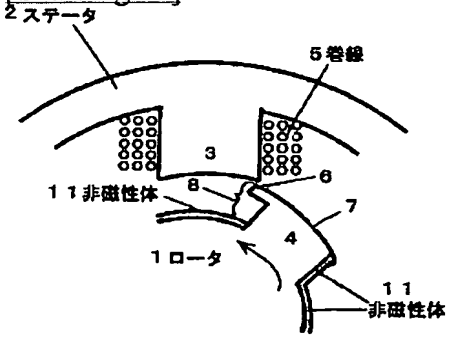
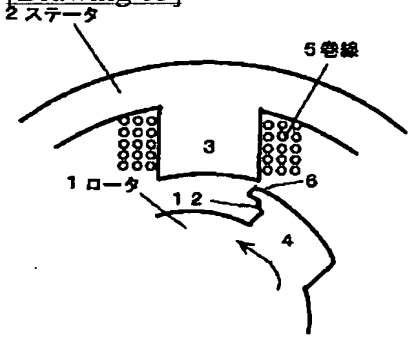


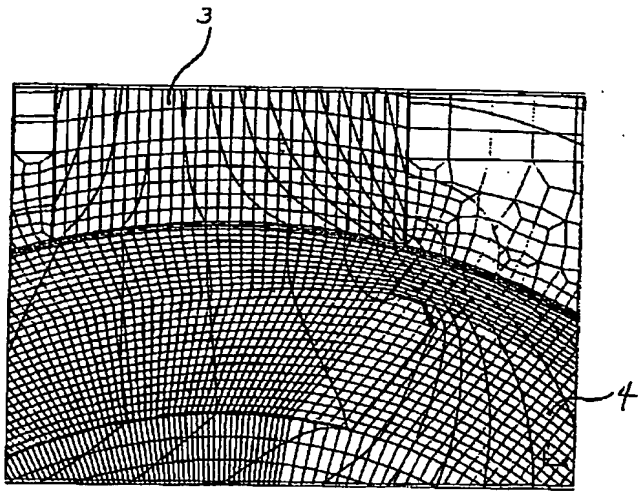
[Drawing 12]



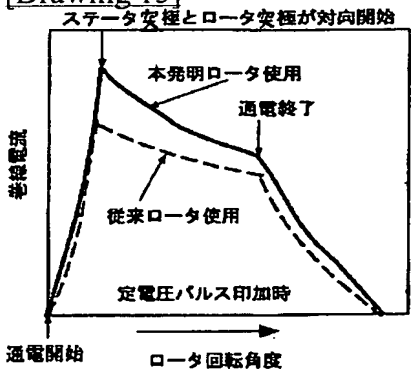
[Drawing 13]



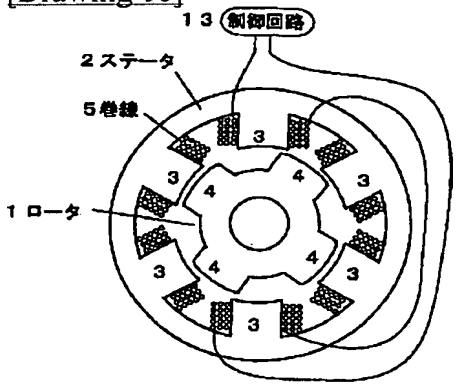
[Drawing 14]



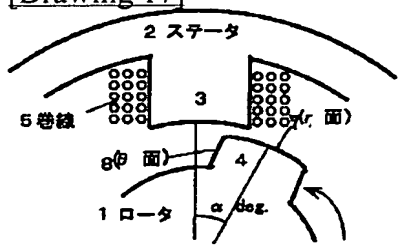
[Drawing 15]



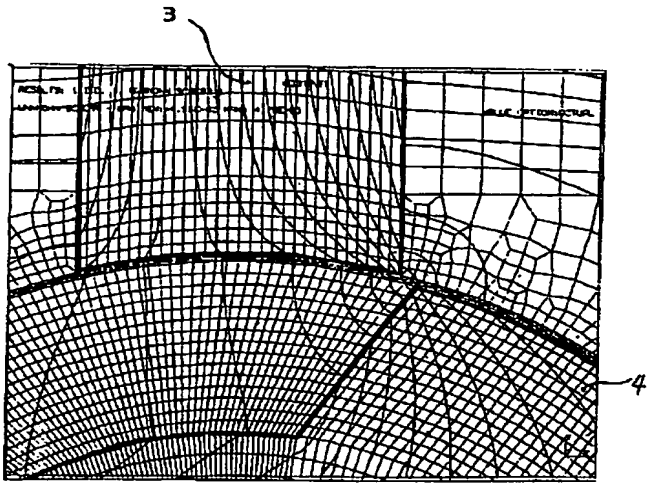
[Drawing 16]



[Drawing 17]



[Drawing 18]



[Translation done.]